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REPORT ON POLLUTION OF THE ST. MARYS AND AMELIA ESTUARIES GEORGIA - FLORIDA

Thomas P. Gallager

Environmental Protection Agency
Athens, Georgia

August 1971

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Southeast Water Laboratory
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GEORGIA-FLORIDA

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INTRODUCTION

This report contains survey results which indicated that pollution of the St. Marys and Amelia estuaries in Georgia and Florida have resulted in deleterious water quality which interfered with legitimate water uses in both states.

Data contained herein are based on the results of water quality surveys conducted by the Federal Water Pollution Control Administration[1/] in 1967. Information on water use was obtained from the U. S. Public Health Service, Georgia Conservation Department, Florida Park Service, and the Florida Marine Welcome Station at Fernandina Beach. Waste disposal data were obtained from the Florida State Board of Health, Georgia Water Quality Control Board, Department of Health of Nassau County, Florida, and the City of Fernandina Beach, Florida. Additional information was received from the Rayonier, Inc. and Container Corporation of America plants in Fernandina Beach, Florida, and from Gilman Paper Company in St. Marys, Georgia.

The generous assistance provided by the above representatives of Federal, state, municipal and industrial agencies is gratefully acknowledged.

1/ Now, the Environmental Protection Agency.

SUMMARY AND CONCLUSIONS

The discharge of untreated and inadequately treated municipal and industrial wastes into the Amelia River, St. Marys River, and tributary streams caused serious water quality degradation and interfered with water uses in the coastal waters of Georgia and Florida. More than 982,000 population equivalents (PE)[1/] of 5-day biochemical oxygen demand (BOD_5) were discharged into these waters -- 710,000 PE (72 percent) into Florida waters and 272,000 PE (28 percent) into Georgia waters.

Untreated wastes discharged from the Rayonier, Inc. and Container Corporation of America paper mills and inadequately treated sewage from the City of Fernandina Beach caused dissolved oxygen in the Amelia River to be depleted to a mean value of 2.0 mg/l with a minimum observed value of 0.6 mg/l. Bottom deposits of organic material were present in the immediate vicinity of the outfalls of the paper mills and bottom organisms sensitive to a polluted environment were scarce throughout the study reach of the Amelia River. Total coliform bacteria densities in the Amelia River exceeded 1,000/100 ml which was considered minimal for direct contact recreation. Pollution from waste discharges limits the use of the river for recreation and fishing activities. There is substantial development oriented toward these uses as evidenced by Fort Clinch State Park and the Florida Marine Welcoming Station at Fernandina Beach. Although hydrography and location are favorable, the Amelia River and tributary system is not suitable for the propagation and harvesting of commercial shellfish due to deleterious water quality.

1/ Population equivalent (PE) based on 0.17 lbs. of BOD_5 per capita per day.

The oxygen demand of approximately 36 percent (184,000 PE) of the wastes from Rayonier, Inc. and 16 percent (31,500 PE) of the wastes from Container Corporation are satisfied within the Amelia River. The remainder is exchanged to the St. Marys and the Atlantic Ocean on each tidal current cycle. However, because of the greater dilution and very rapid diffusion afforded by the St. Marys River, wastes discharged to the Amelia River have a negligible effect on the quality of water in the St. Marys River. Both paper mills have been cited by the Florida Air and Water Pollution Control Commission as polluters and have been ordered to abate their wastes.

Untreated domestic and industrial wastes discharged by the Gilman Paper Company grossly pollute the North River in Georgia and affect the interstate waters of the St. Marys River for about one and one-half miles on either side of the North River junction. The principal effects of waste assimilation in the St. Marys River are exercised on the seaward side below the confluence with the North River. Dissolved oxygen is depleted in the North River during the ebb phase of the current cycle. Dissolved oxygen with a minimum of 2.2 mg/l was observed in the St. Marys River below the North River, and 47 percent of the samples were below 4 mg/l.

The Jolly River, a strait entering the marsh areas on the Florida shore, is slightly affected by wastes in the St. Marys River. Minimum dissolved oxygen was 3.4 mg/l, and 10 percent of the samples were less than 4 mg/l.

Based on dissolved oxygen observations and because of the nature of the current cycle, it is highly unlikely that Cumberland Sound is adversely affected by waste discharges in the study area. The better quality water in Cumberland Sound has a net beneficial effect on water quality in the St. Marys River.

RECOMMENDATIONS

1. To enhance water quality in the Amelia River and its tributary system and to permit proper development of many legitimate water uses, an immediate abatement program should be undertaken. Under this program, Rayonier, Inc. and Container Corporation of America should:
   - Separate domestic and industrial wastes;
   - Provide the highest degree of secondary treatment to the industrial wastes;
   - Diffuse the treated industrial wastes across the channel to provide complete mixing and to eliminate the heavily polluted conditions along the Fernandina Beach waterfront;
   - Provide secondary treatment and chlorination to the domestic wastes throughout the year.
2. The effects of the Rayonier wastes discharged to the Atlantic Ocean should be evaluated. If this waste is causing adverse effects to water quality and uses, an abatement program involving adequate treatment is required.
3. Gilman Paper Company should proceed with an abatement program which will provide the highest degree of secondary treatment to municipal and industrial wastes and year-round chlorination for domestic wastes.
4. The City of Fernandina Beach should expand existing primary treatment facilities to a secondary plant and provide disinfection to the wastes on a year-round basis.
5. St. Marys, Georgia, should construct a collection system and provide secondary treatment and chlorination to its wastes on a year-round basis.

6. The Quin Menhaden Company should improve in-plant housekeeping and install evaporators for the waste waters to protect against fish kills caused by sporadic releases of process water to Egans Creek.
7. The State of Florida should upgrade the use classification of the Amelia and St. Marys Rivers from navigation utility and industrial use to a classification consistant with water uses.

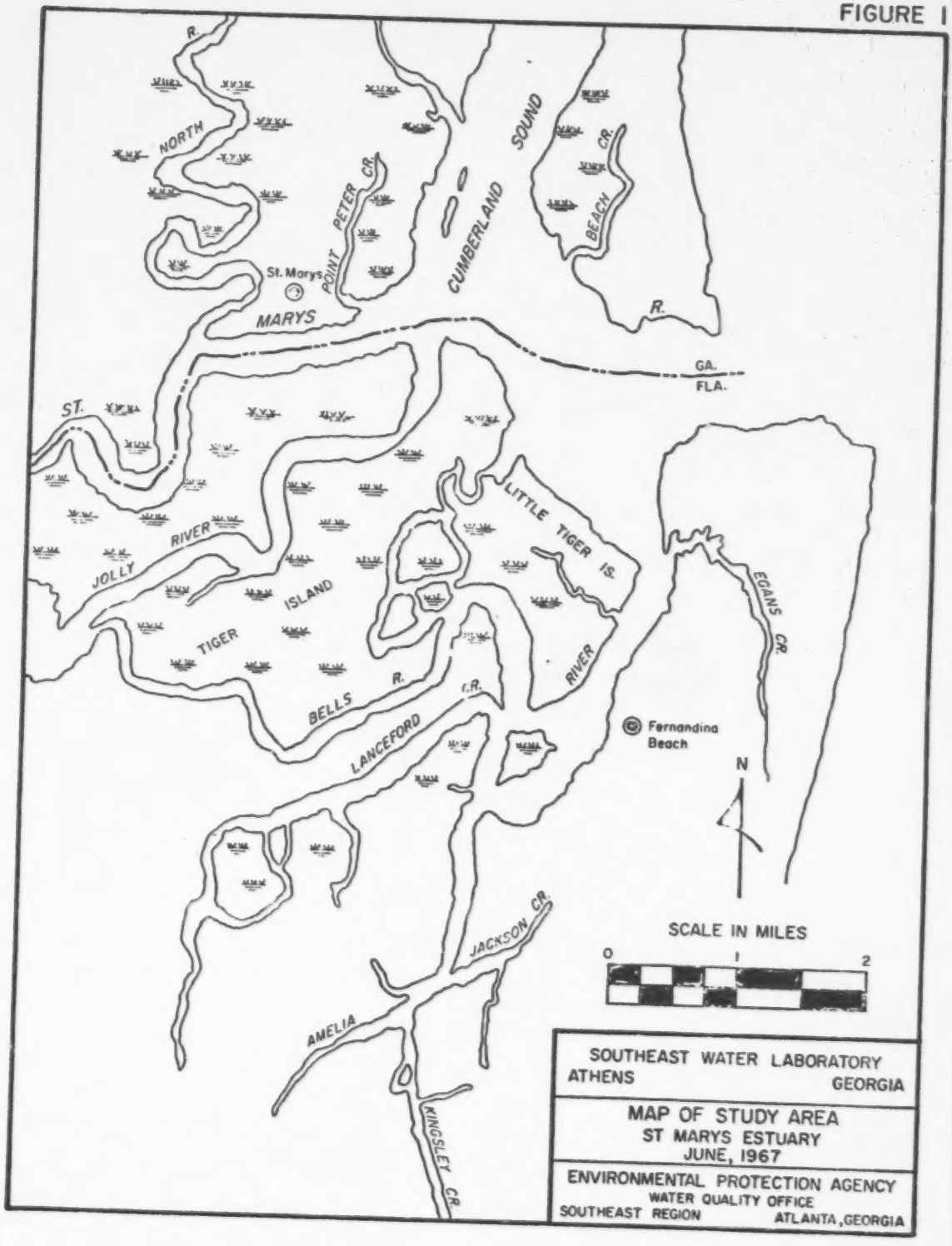
STUDY AREA

The St. Marys River is located in southeastern Georgia and northeastern Florida and forms the boundary between the states for its entire length of about 125 miles. The principal area of consideration for this report is the lower ten miles of the river. Included in the drainage system of this section of the St. Marys River are the southern half of Cumberland Sound located entirely within Georgia and the northern portion of the Amelia River, as well as the marsh areas bordering it which are entirely within Florida. A map of the study area is shown in Figure 1.

The lower reach of the St. Marys River is controlled by tidal currents and, in turn, controls parts of Cumberland Sound and the Amelia River. Since the only outlet to the Atlantic Ocean is through the St. Marys channel, water movement is such that current cycles begin almost simultaneously at all locations. Measurable surface water runoff occurs only in the St. Marys River -- the other waterways act as tidal straits. The fresh water discharge, however, is relatively insignificant when compared to channel volume and does not materially influence net travel time of water through the system. The average annual discharge through 34 years of record is 652 cfs. The drainage area upstream from the tidal influence is 720 square miles.

The lower basin physiography is mainly characterized by low lying marshlands with little topographic relief. Maximum elevations are 90 feet above mean sea level.

FIGURE 1


R.
NORTH
POINT PETER CR.
CUMBERLAND SOUND
CR.
BEACH
St. Marys
MARYS
R.
GA.
FLA.
ST.
RIVER
JOLLY
ISLAND
TIGER
LITTLE TIGER IS.
EGANS CR.
BELLS
R.
C.R.
RIVER
LANCEFORD
Fernandina Beach
N
JACKSON CR.
AMELIA
KINGSLEY CR.
SCALE IN MILES
0
1
2
SOUTHEAST WATER LABORATORY
ATHENS
GEORGIA
MAP OF STUDY AREA
ST MARYS ESTUARY
JUNE, 1967
ENVIRONMENTAL PROTECTION AGENCY
WATER QUALITY OFFICE
SOUTHEAST REGION
ATLANTA, GEORGIA

The region is sparsely settled with minimal industrial diversification. Principal land use is for forestry and agriculture. The major municipalities are Fernandina Beach, Florida, on Amelia Island (population 7,300) and St. Marys, Georgia (population 3,300).

Economic development has centered on the pulp and paper processing industry in both Georgia and Florida. Rayonier Corporation and the Container Corporation of America have located mills in Fernandina Beach employing about 500 and 800 people respectively. Gilman Paper Company has a mill located at St. Marys, Georgia, which employs about 1,600 people. A large commercial fishing fleet, with associated fish processing plants, is also located at Fernandina Beach.

WATER USE

The major water uses of the St. Marys and Amelia Rivers are contact (swimming-water skiing) and non-contact (boating) recreation, fishing, navigation and waste disposal.

Cumberland Sound (part of the St. Marys River) and the Amelia River are part of the Intracoastal Waterway, an inland water passage located along the Eastern and Gulf coasts. The City of Fernandina Beach is the northernmost municipality in Florida along this route, and thus, represents the first and last impression of the state for transient boaters. Fernandina Beach has invested $300,000 in a marine welcome station which includes a large marina and boat launching ramp. This installation is located at the center of the harbor at Fernandina Beach and is designed to attract and encourage boating and water contact sports in the Amelia River. From January 1965 to April 1967, 3,229 yachts containing 10,107 people have stopped at Fernandina Beach. A total of 4,997 yachts passed the waterfront without stopping. These figures indicate that the Amelia River and the rest of the study area in the Intracoastal Waterway are very heavily utilized for pleasure boating. Tourism is also a great attraction of the area. Over the same period of time quoted above, 70,911 people stopped at the marine welcome station in automobiles to obtain information about the tourist attractions at Fernandina Beach and other Florida areas.

Recreational facilities on Amelia Island attract over 250,000 people annually. Fort Clinch State Park is located on the northern tip of Amelia Island and has facilities for camping and boat launching on the

Amelia River. Developed beaches are located on the Amelia River adjacent to camping areas. Although these waters are designated as polluted and unsafe for swimming by the Florida State Board of Health and the Nassau County Department of Health, individual campers were observed swimming and wading by FWPCA personnel in June 1967. Extensive boating and water skiing activity is prevalent. During 1966, according to the Florida Park Board, approximately 64,000 people used the campgrounds, and more than 200,000 people visited the park.

Sport fishing is a popular activity principally in the St. Marys River outlet channel to the Atlantic Ocean and in the marshland areas bordering the St. Marys and Amelia Rivers. In a promotional brochure for Fort Clinch State Park, the Florida Park Board advertises that at least nine species of highly desirable sport fish are present. They also state that crab and shrimp are plentiful.

All of these uses are interfered with by the disposal of untreated and inadequately treated municipal and industrial wastes discharged to the study area. The State of Georgia has initiated an active program of pollution abatement for the wastes discharged in its jurisdiction. It is estimated that these sources will be adequate for treating their wastes by 1972.

The two paper mills at Fernandina Beach, Florida, discharge untreated wastes which have heavily polluted the Amelia River and which, as noted previously, have caused the waters around Fort Clinch State Park to be declared unsafe for contact and non-contact sports. The State of Florida has classified these waters as navigational. This classification requires only minimal water quality. The Board of County Commissioners of Nassau County has passed and transmitted to the Governor of Florida a resolution

objecting to this classification and recommending a recreation and fishing classification as more suitable.

In addition to the present activities, a potential use which is deleteriously affected by indiscriminate waste discharges is commercial shellfish propagation and harvesting. The entire study area within Georgia is closed to this activity because of pollution. In Florida, water areas not shown as approved or conditionally approved are prohibited to the harvesting of shellfish pending evaluation of water quality and classification by the State Board of Health. The waters of the northern Amelia River and its tributaries have not been classified and, therefore, are considered prohibited to shellfish harvesting.

Except in the immediate vicinity of the waste effluents, the marshland areas in and around the St. Marys and Amelia Rivers do support extensive beds of living oysters. These areas have not developed because the waste discharges to the rivers cause water quality conditions which are unacceptable for the harvesting of shrimp, shellfish, and other types of marine life. In addition, the edible varieties that are present are unmarketable due to unpalatable tastes imparted from the waste effluents.

To contrast the effects of these waste discharges on shellfishing, a comparison with the Nassau River estuary system immediately to the south of the study area is presented. This area is similar in topography and location to the St. Marys-Amelia system. Information compiled by the Bureau of Commercial Fisheries show that in 1966, a total of 38,352 pounds of shellfish were taken from the Nassau system compared to only 386 pounds from the St. Marys-Amelia system. In 1965, the respective figures were 29,669 pounds to 552 pounds.

It is obvious that the use of the Amelia and St. Marys Rivers for

the transport of untreated wastes seriously interferes with and deleteriously affects all other water uses. Waste transportation should not be considered a legitimate water use.

WASTE DISCHARGES

The estuarine portions of the St. Marys and Amelia Rivers have been extensively used for the disposal of municipal and industrial wastes which causes serious water quality degradation. Table I summarizes the domestic and industrial waste discharges in the study area. Waste discharge data are given in terms of population equivalents (PE). One population equivalent is equal to the amount of 5-day biochemical oxygen demand (BOD_5) discharged by one person per day (0.17 lbs. BOD_5/capita/day).

More than 982,000 PE of organic waste material is discharged into the estuarine waters of the Amelia River, St. Marys River and the North River each day. Of this total, approximatly 72 percent or 710,000 PE are discharged into Florida waters, and 28 percent or 272,000 PE are discharged into Georgia waters. Industrial waste discharges account for 976,000 PE or 99.3 percent of the total population equivalent with the remaining 6,300 PE from domestic waste sources. Figure 2 shows location and relative quantities of the principal waste discharge.

The major industrial waste problems in the study area are the untreated wastes from the Rayonier, Inc. and Container Corporation of America pulp and paper mills in Fernandina Beach, Florida, and from the Gilman Paper Company mill in St. Marys, Georgia. The Rayonier Mill, a sulfite mill, employs acid base cooking liquors to free wood fibers from other constituents of wood in the manufacture of pulp. The other two mills are sulfate or kraft mills which utilize alkaline cooking liquors for the same purpose.

TABLE I

WASTE DISCHARGES
ST. MARYS RIVER STUDY AREA

SOURCE	TREATMENT	ESTIMATED BOD_5 POPULATION EQUIVALENTS[1]
A) Domestic Wastes		
Fernandina Beach, Fla.	Primary	3,000
St. Marys, Ga.	None	3,300
	Total	6,300
B) Industrial Wastes[2]		
Rayonier, Inc., Fla.	None	510,000
Container Corp., Fla.	None	197,000
Gilman Paper Co., Ga.	None	269,000
	Total	976,000
	Grand Total	982,300

[1] One population equivalent = 0.17 lbs. BOD_5/capita/day.

[2] Domestic wastes from the sources are included in these figures.

Although differences exist among the exact manufacturing processes employed by individual mills, similar basic steps are followed by all mills (Figure 3).[1] The kraft process is more amenable to chemical recovery and water re-use than the sulfite process. The sulfite process normally produces between three to six times more organic wastes than the kraft process for the same amount of material produced. Major characteristics of all paper wastes are: the high concentrations of suspended solids which settle in receiving waters and form sludge deposits and high biochemical oxygen demand, toxicity and color.

The Rayonier sulfite plant discharges a total of 510,000 PE of untreated wastes to the Amelia River. The acid waste resulting from the cooking process amounting to about 1.6 MGD, with a pH value of about 2, is discharged into the Atlantic Ocean approximately one mile offshore. This discharge is reported by Rayonier to be 810,000 PE. The effects of this portion of the waste load have not been evaluated although there have been reports of foaming on the Atlantic beaches. Based on 1965 production figures, Rayonier discharges 550 pounds of BOD_5 for each ton of paper produced. The domestic wastes of about 500 employees are also discharged untreated with the process wastes.

The Container Corporation of America kraft mill discharges untreated wastes of approximately 197,000 PE to the Amelia River. This total includes the domestic waste effluent of approximately 800 employees. Based on 1965 production figures, about 40 pounds of BOD_5 are produced per ton of paper.

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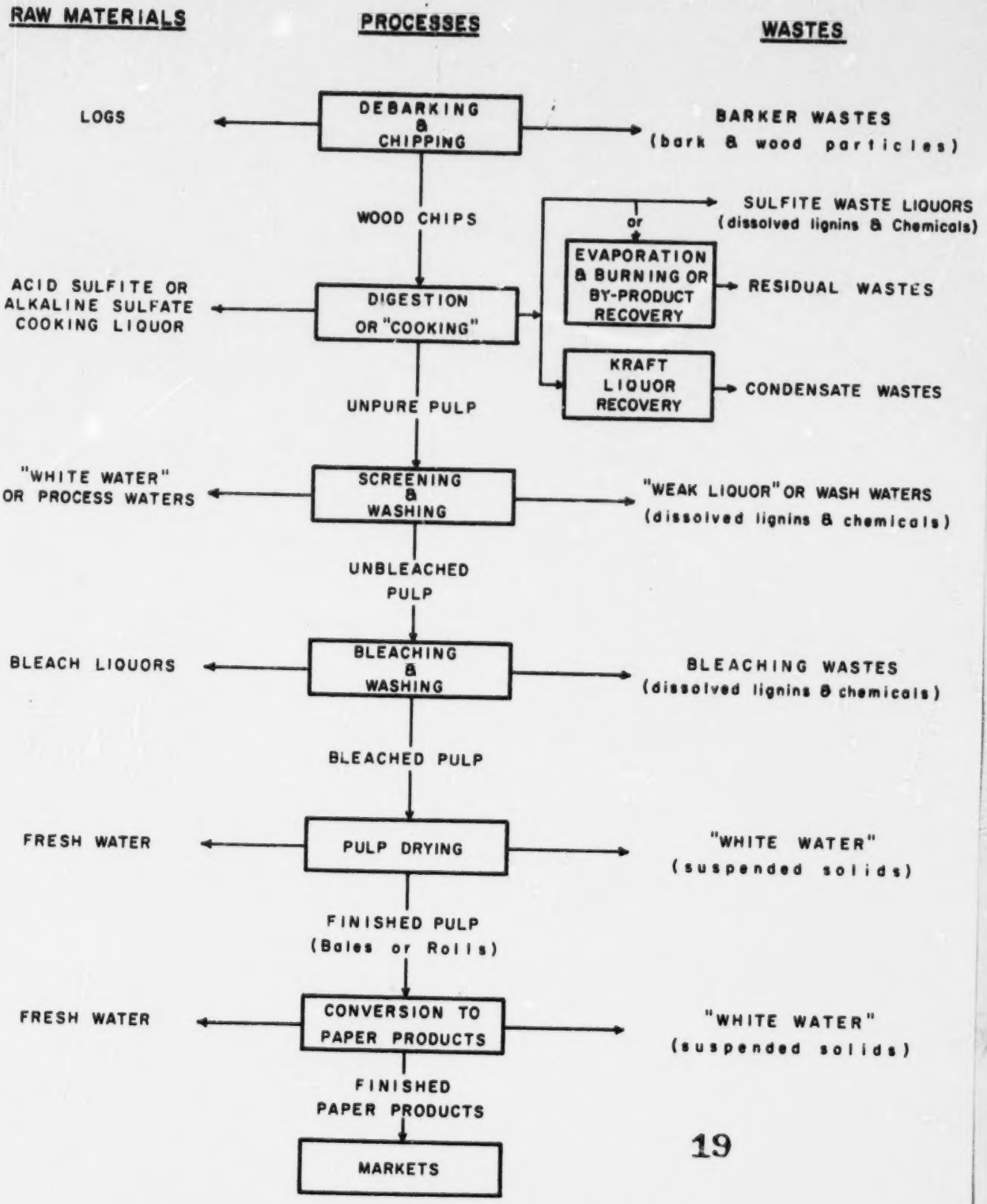
[1] Pollutional Effects of Pulp and Paper Mill Wastes in Puget Sound - USDI, Federal Water Pollution Control Administration, Portland, Oregon, and Washington State Pollution Control Commission, Olympia, Washington, March 1967.

FIGURE 3

SIMPLIFIED SCHEMATIC OF PULP AND PAPER PROCESSING



The Gilman Paper Company of St. Marys, Georgia, is a kraft mill which discharges approximately 269,000 PE of untreated wastes to the North River, a tidal tributary of the St. Marys River. This includes the domestic wastes of 1,600 employees. The company has been ordered to provide secondary treatment for its wastes by the Georgia Water Quality Control Board. Based on 1965 production figures, the BOD_5 produced per ton of paper is 50 pounds.

The only other industrial pollution in the study area is from the Quinn Menhaden Company fish meal processing plant at Fernandina Beach. This operation is seasonal from about April to October of each year. In the process, fish are cooked, and the oil and meal are extracted. The oil is separated, and water is evaporated to produce the meal. During July 1966, a discharge of the oil-meal-water mixture to Egans Creek -- an inlet of the Amelia River at Fernandina Beach -- suppressed the dissolved oxygen in the receiving waters and caused a major fish kill. The Florida State Board of Health has recommended that this plant install evaporators for the waste waters and that in-plant housekeeping be improved.(2)

The principal sources of domestic waste in the study area are the Cities of Fernandina Beach, Florida, and St. Marys, Georgia. A primary sewage treatment plant serving Fernandina Beach discharges approximately 3,000 PE into the Amelia River. This plant removes an estimated 30-50 percent of the influent BOD_5. Chlorination of the effluent is presently practiced throughout the year. However, during the November 1965 study, the effluent was not chlorinated, and the mean total coliform bacteria

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(2) Survey of Egans Creek - Nassau County - July 29 to August 3, 1966, Florida State Board of Health, Bureau of Sanitary Engineering.

density was 34,000,000/100 ml. Fecal coliform, which is confined to the digestive tracts of man and animals, averaged 28,000,000/100 ml in the plant effluent. The municipal discharges and domestic wastes from Container Corporation and Rayonier mills (1,300 PE) are the major sources of fecal coliform bacterial pollution in the Amelia River and its tributary system. An inadequate waste collection system serving St. Marys, Georgia, discharges untreated sewage from 3,300 people to the St. Marys River. The municipality has been ordered to provide a collection system and secondary treatment with disinfection for its wastes by the Georgia Water Quality Control Board. These waste discharges along with domestic discharges from 1600 employees at the Gilman Paper Company contribute to the bacterial contamination of the St. Marys River and its tributaries.

EFFECTS OF WASTE DISCHARGES ON WATER QUALITY

SAMPLING STATIONS

Two water quality surveys were conducted by the Federal Water Pollution Control Administration[1/]. The November-December 1965 survey was designed to obtain data for comprehensive planning purposes. The June 1967 survey was designed to supplement the previous data collected. A description of all sampling stations is contained in Table II, and the station locations are shown in Figure 4.

DYE TRACER STUDIES

In order to describe the area of influence of each of the major waste sources, a quantity of Rhodamine B fluorescent dye was injected at each pulp and paper mill outfall during November 1965, and the path of the effluent was traced through one ebb current cycle.

Dye was introduced to the Amelia River at the Rayonier, Inc. outfall about one and one-half hours after the current had started to ebb northward toward the St. Marys River. Within fifty minutes, the dye had spread over approximately three-quarters of the ship channel and was off the Fernandina Beach city docks opposite the mouth of Lanceford Creek and Bells River. Strong ebbing currents from Lanceford Creek and Bells River forced the dye mass closer to the shore of Amelia Island. However, by the time the dye mass had reached the Container Corporation plant, about one hour after injection, the dye had covered the entire ship channel. At Fort Clinch State Park, the ebbing current from the St. Marys River kept the tracer, representing the Rayonier effluent, directly adjacent

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[1/] Now, the Environmental Protection Agency

TABLE II

DESCRIPTION OF SAMPLING STATIONS

A. Amelia River

Station Number		Location
Nov.-Dec. 1965	June 1967	
649010	SM-10	Channel of St. Marys River on seaward side of Fort Clinch
	A-9	Buoy #17 in Amelia River
	A-8	Between Buoy #18 and Amelia Island in Amelia River
649020	A-7	Between Buoys #19 and #20 in Amelia River Channel
	A-6	In Amelia River Channel off southern end of Container Corp. railroad yards
	A-5A	Juncture of Bells River and Lanceford Cr.
649040	A-5	Buoy #22 in Amelia River
	A-4	Buoy #26 in Amelia River
649060	A-3	Buoy #1 in Amelia River
	A-2	Buoy #3 in Amelia River
649080	A-1	Railroad bridge in Amelia Riv. north of Hwy. A1A bridge

B. St. Marys River

Station Number		Location
Nov.-Dec. 1965	June 1967	
649010	SM-10	Channel of St. Marys River on seaward side of Fort Clinch
	SM-9	Buoy #15 in St. Marys River
128710	C-8	Between Buoys #16 and #17 in channel of Cumberland Sound
	JR-7	Mouth of Jolly River

TABLE II (Cont'd)

Station Number		Location
649200	SM-6	Off Georgia shore 1/4 way across channel near Point Peter
	SM-5	Between Georgia shore and Buoy #3 in St. Marys River
	N-4	First bend upstream in North River
	N-3	Second bend upstream in North River
	N-2	Third bend upstream in North River
128750		Bridge over North River
	SM-1	Between Georgia shore and Buoy #10 in St. Marys River
	SM-0	Buoy #13 in St. Marys River
	SM-00	St. Marys River channel off unnamed point just above St. Marys, Georgia

C. Bells River

Station Number		Location
Nov.-Dec. 1965	June 1967	
649045		Bells River @ Highway 107 in Chester, Florida

to the beaches, boat ramps, and camping area of the park. At about Fort Clinch itself, the dye mixed with the waters of the St. Marys River and spread out across the St. Marys channel where it became too dilute for continued observations.

Dye was introduced into the Container Corporation waste flow about the time that maximum ebb current was occurring in the Amelia River. The dye patch moved in the same manner as that observed from Rayonier and remained relatively concentrated just off the recreational areas of Fort Clinch State Park within one hour after injection. As with the Rayonier patch, ebbing waters from the St. Marys River prevented immediate mixing across the channel entrance. However, as the dye passed Fort Clinch it began to disperse across the channel but did not reach the Georgia shore before flood current began.

The conclusion from these two current studies is that within one ebb current cycle the discharge from the Container Corporation and Rayonier Inc. can cause serious pollution of the direct and indirect contact recreation areas of Fort Clinch State Park. The effluent does cross the Georgia-Florida state line at a point in the St. Marys channel approximately off Fort Clinch but is markedly diluted by the much greater volumes of water ebbing from St. Marys River and Cumberland Sound. No tracer studies have been made of the area of influence of these discharges on the flooding current.

The Amelia River is a tidal strait, and water movement is by means of tidal currents only. There is insufficient fresh water to cause a net displacement. Wastes reaching the St. Marys channel off Fort Clinch will not be carried back into the Amelia River. The Container Corporation outfall and the Rayonier outfall are 2.2 miles and 3.8 miles, respectively,

from the St. Marys channel off Fort Clinch. A review of current velocities[3] over the ebb and flood cycle in the Amelia River shows that wastes discharged from Rayonier during the last four and one-half hours of the flooding current and the first three and one-half hours of the ebb current will reach the exit channel in the St. Marys River. Wastes discharged from Container Corporation during the entire flood current and the first four and one-half hours of the ebb current will also be carried out of the Amelia River. Based on an average 12.5 hour tidal cycle and assuming a constant rate of waste discharge, it is estimated that about 64 percent of the Rayonier, Inc. wastes and 84 percent of the Container Corporation wastes are exchanged on each cycle.

Dye was released from a point in the North River approximately 600 feet south of the outfall of the Gilman Paper Company about one and one-half hours after maximum ebb current had been reached. Within one and one-half hours after injection, the tracer had moved into the St. Marys River. As ebbing continued in the St. Marys and North River, the dye mass moved across the main channel of the river until the major portion was found just off the marshland areas of the Florida shore. During approximately three hours of ebbing tide over which this study was conducted, the mass reached to Point Peter. On the flooding current, the dye representing the Gilman effluent remained along the Florida shore

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(3) Tidal Current Tables 1965, Atlantic Coast of North America, U. S. Coast and Geodetic Survey.

and was carried upstream in the St. Marys River past the mouth of the North River to a point just downstream of the City of St. Marys. The conclusion from this limited tracer study is that wastes from the Gilman Paper Company do cross the Georgia-Florida state line in significant concentrations.

DISSOLVED OXYGEN

Sewage and many industrial wastes contain organic matter which decomposes and exerts an oxygen demand in the receiving waters. In the process of decomposition, dissolved oxygen in the receiving waters is reduced below its normal level of concentration to satisfy the biochemical degradation of the organic material. High concentrations of oxygen demanding material will cause an excessive reduction of the dissolved oxygen resources which, in turn, will result in a reduction of desirable aquatic life and fish population. The States of Georgia and Florida require a minimum dissolved oxygen concentration of 4 mg/l in waters which are classified for recreation or fishing uses. To determine dissolved oxygen concentrations under warm water temperature conditions, an average of nineteen samples per station were collected from twenty-two stations established in the study area during June 1967. These data are presented in Table III and are shown in Figures 5 and 6.

In the Amelia River, dissolved oxygen was reduced to a low mean value of 2.0 mg/l just north of the mouth of Jackson Creek, a point south of all waste discharges. At an average water temperature of 26°C and chloride concentration of 19,000 mg/l, this represents dissolved oxygen saturation of 30 percent. The minimum dissolved oxygen recorded at this location was 0.6 mg/l. Dissolved oxygen was below 4 mg/l for the entire

TABLE III

DISSOLVED OXYGEN
ST. MARYS RIVER STUDY AREA
June 1967

STATION	DISSOLVED OXYGEN (mg/1)			PERCENT <4 (mg/1)
	Mean	Maximum	Minimum	
Amelia River				
A-1	2.1	2.9	1.2	100%
A-2	2.0	2.9	0.6	100%
A-3	2.4	4.0	0.7	96%
A-4	3.1	5.6	1.2	63%
A-5	4.1	6.2	1.5	50%
A-6	4.2	6.3	1.7	41%
A-7	4.7	6.7	2.3	32%
A-8	5.2	6.8	3.1	20%
A-9	5.3	6.7	3.4	22%
Lanceford Creek - Bells River				
A-5A	3.9	4.9	2.0	43%
St. Marys River				
SM-00	4.6	5.2	4.2	0%
SM-0	4.4	5.2	4.1	0%
SM-1	4.5	5.3	3.5	15%
SM-5	3.9	4.9	2.2	47%
SM-6	4.5	5.4	3.0	21%
SM-9	5.5	6.7	4.1	0%
SM-10	5.9	7.2	3.7	4%
North River				
N-2	1.6	4.0	0.0	95%
N-3	2.3	4.5	0.0	75%
N-4	2.7	5.0	0.0	60%
Jolly River				
JR-7	4.8	5.4	3.4	10%
Cumberland Sound				
C-8	5.6	6.4	4.0	0%

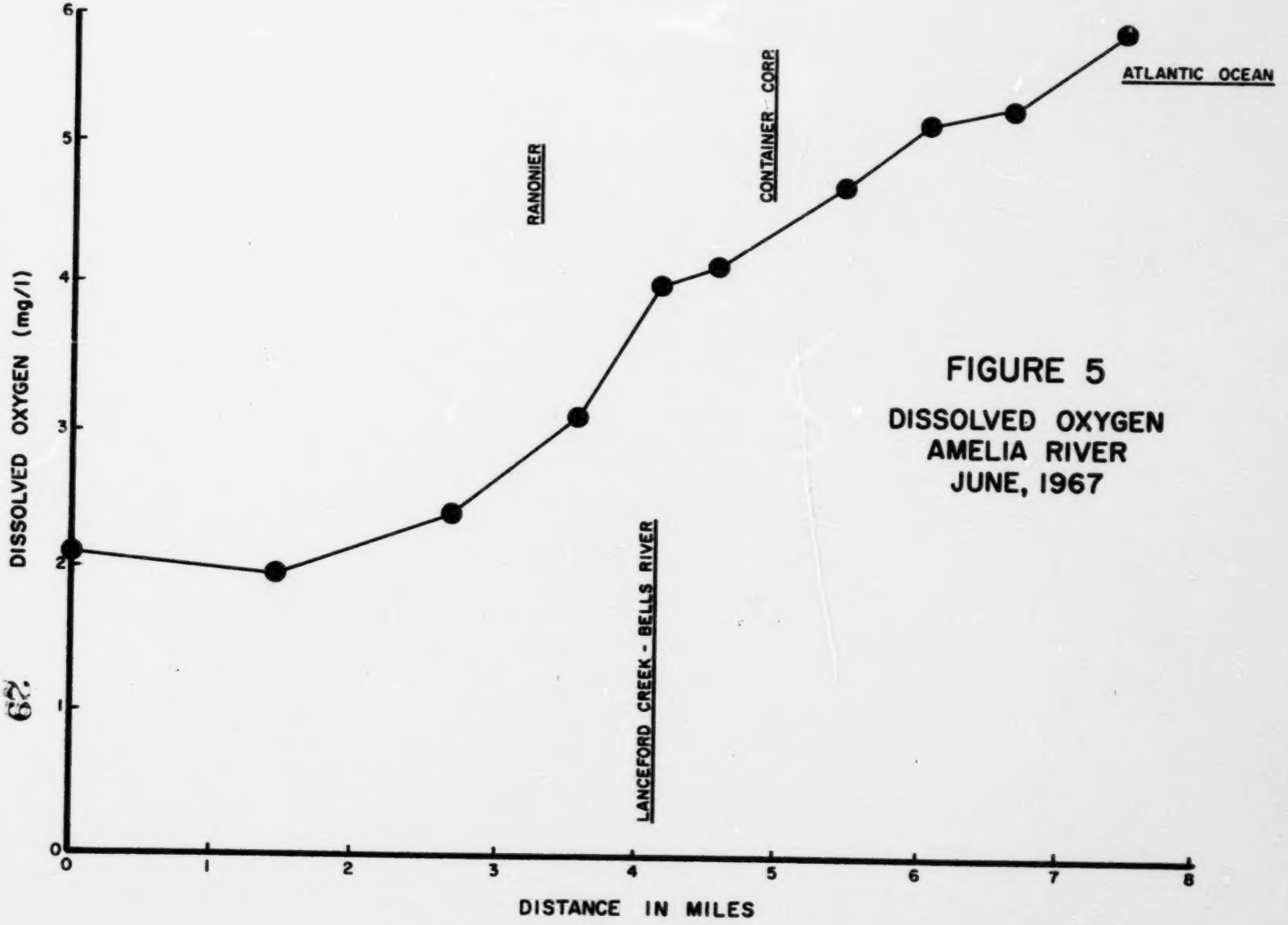


FIGURE 5

DISSOLVED OXYGEN
AMELIA RIVER
JUNE, 1967

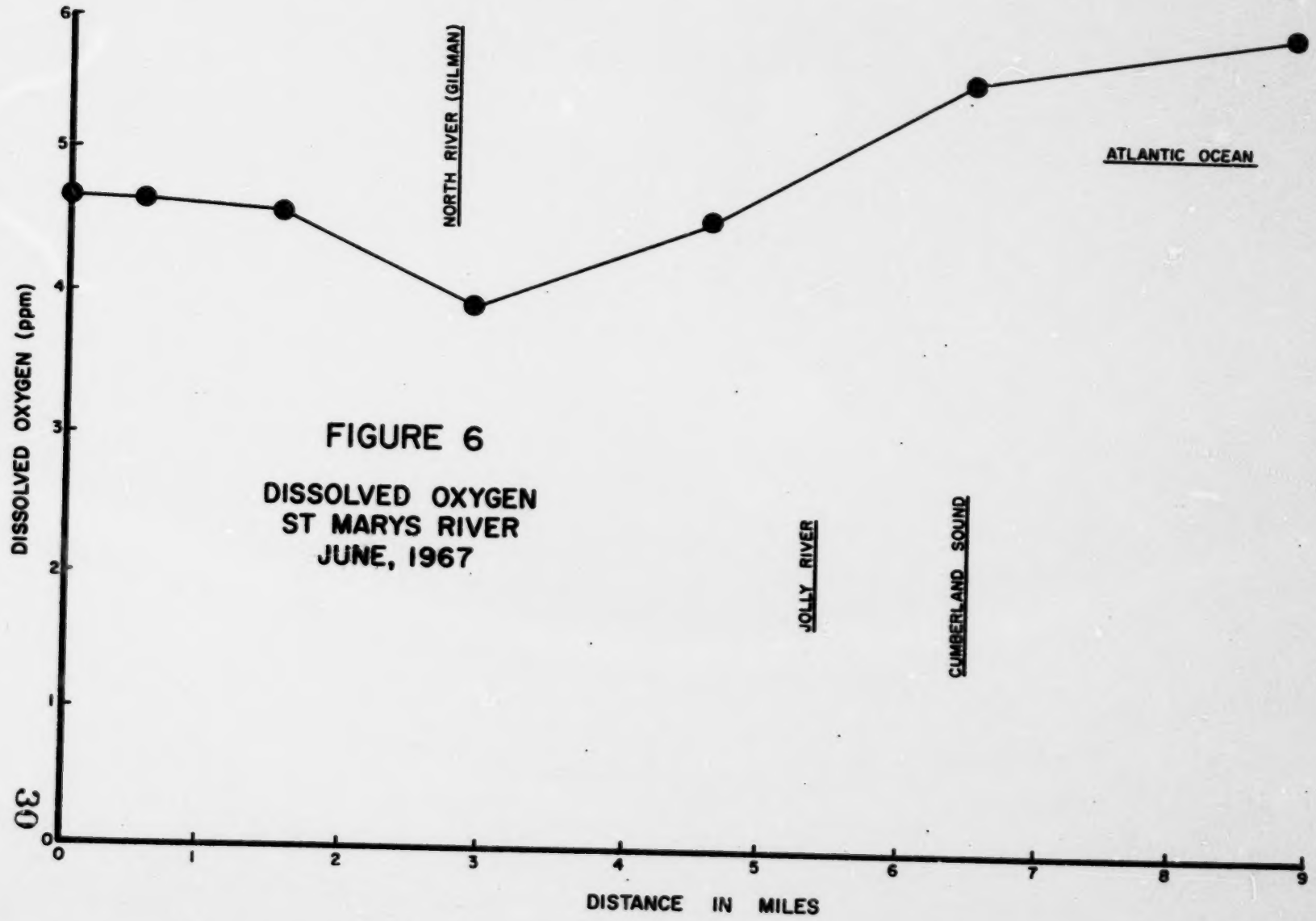


FIGURE 6

DISSOLVED OXYGEN
ST MARYS RIVER
JUNE, 1967

reach of the Amelia River south of the Lanceford Creek and Bells River confluences to the A1A bridge, the uppermost sampling location. In the mouth of Lanceford Creek and Bells River, the dissolved oxygen averaged 3.9 mg/l with a minimum value of 2.0 mg/l. North of this point dissolved oxygen recovers rapidly. Off the recreation area at Fort Clinch State Park, the average dissolved oxygen was 5.3 mg/l or 79 percent of saturation; however, a minimum value of 3.4 mg/l was recorded.

The satisfactory dissolved oxygen concentrations in the Amelia River north of Lanceford Creek were principally due to tidal exchange with the ocean. Rayonier, Inc. wastes discharged during the flooding phase of the current cycle moved south. Container Corporation wastes also moved south and penetrated into Lanceford Creek and Bells River as well as the southern portions of the Amelia River. On the basis of dye studies, current velocities and the dissolved oxygen profile in the Amelia River, it is estimated that about 36 percent or 184,000 PE and 16 percent or 31,500 PE of the daily discharges from Rayonier and the Container Corporation, respectively, satisfies its oxygen demand within the Amelia River. Therefore, Rayonier, Inc. wastes are causing approximately 85 percent of the dissolved oxygen depletion in the Amelia River and practically all of the remaining 15 percent results from Container Corporation's discharge. Most of the waste assimilation occurs in the Amelia River south of the Lanceford Creek junction. Wastes discharged to the Amelia River have minor effect on the quality of waters in the St. Marys River due to the greater dilution and rapid diffusion in the St. Marys River.

Dissolved oxygen in the St. Marys River had mean values below 4 mg/l in the immediate area of the confluence with the North River which receives the untreated wastes from the Gilman Paper Company. Downstream from the North River, dissolved oxygen in the St. Marys River averaged 3.9 mg/l with a minimum value of 2.2 mg/l. Forty-seven percent of the samples had dissolved oxygen concentrations below 4 mg/l. One and one-half miles seaward the dissolved oxygen level was 4.5 mg/l, and the minimum value at this station was 3 mg/l. Twenty-one percent of the samples had dissolved oxygen less than 4 mg/l. Upstream of the North River confluence and downstream of the City of St. Marys, dissolved oxygen averaged 4.5 mg/l; however, dissolved oxygen in 15 percent of the samples was below 4 mg/l, and the minimum was 3.5 mg/l. Wastes from the North River cause water quality degradation of the St. Marys River near the junction of the two waterways. However, flow from the North River is rapidly diffused and diluted in the St. Marys River such that effects diminish rapidly within approximately one and one-half miles on either side of the junction. The nature of the current cycle indicates that the principal effects of waste assimilation from the North River in the St. Marys River are exercised on the seaward side of the confluence with the two rivers.

The North River itself is heavily polluted. Mean dissolved oxygen concentrations were as low as 1.6 mg/l immediately upstream of the Gilman waste discharge. During the ebbing phase of the current cycle, dissolved oxygen is zero. The only time that significant oxygen concentrations were observed was during the flooding current when better quality waters from the St. Marys River enter the North River.

The Jolly River -- a strait entering the marshlands on the Florida shore about two and one-half miles downstream from the North River -- is slightly affected by wastes in the St. Marys River. Dissolved oxygen at this location averaged 4.8 mg/1, but two observations or 10 percent of the samples collected were below 4 mg/1. The minimum dissolved oxygen observed was 3.4 mg/1.

Waters in Cumberland Sound are not adversely affected by wastes discharged in the study area. Dissolved oxygen in the mouth of the Sound averaged 5.6 mg/1. Dissolved oxygen in the St. Marys River above and below Cumberland Sound was 4.5 mg/1 and 5.5 mg/1, respectively. The better quality water in Cumberland Sound very likely has a net beneficial effect on the water quality in the St. Marys River.

COLIFORM DENSITIES

Waste effluents contain fecal coliform bacteria, which is presently the most reliable bacterial measure of fecal pollution. These bacteria are almost always present in the river water which receives some form of waste and have been used as an indication of the probable presence of pathogenic organisms. The coliform group has been used by numerous Federal, State, and interstate agencies concerned with water pollution control as a basis for water quality objectives for various water uses.

Fecal coliform bacteria are found in the intestinal track of man and other warm-blooded animals. The presence of fecal coliform organisms in receiving waters indicates probable contamination by fecal material. The major point sources of bacterial pollution with regard to total coliform in the study area are the effluent from the three paper mills and from the primary sewage treatment plant at Fernandina Beach.

Domestic wastes from the mills and from the municipalities as well as regrowth due to paper mill wastes were the primary sources of fecal coliform densities. Bacterial samples were collected during November 1965 from the receiving waters in the study area. Coliform densities are listed in Table IV and shown in Figure 7.

In this report, coliform densities will be considered in terms of the levels considered minimal for the maintenance of a shellfish production and harvesting area and for recreational purposes. As noted previously, the study area is well situated to support an extensive shellfishing industry as well as a major recreation area. The bacterial quality of water from which shellfish are taken for interstate shipment is governed by the U. S. Public Health Service standard. This standard specifies a median most probable number (MPN) of total coliform organisms of 70 per 100 ml for the production of oysters that may be eaten raw. In waters designated for recreational purposes, the State of Florida requires that coliform concentrations not exceed a mean of 1,000/100 ml for whole body contact use.

The main channel of the Amelia River had coliform bacteria densities exceeding that for body contact recreation. Densities were greatest in the vicinity of the waste outfalls of the two paper plants and the Fernandina Beach sewage treatment plant outfall. At the AlA bridge, total coliform densities had a median of 1,700/100 ml with a maximum value of 4,900/100 ml. Immediately south of the Rayonier outfall, the median total coliform bacteria density was 3,300/100 ml with a maximum value of 13,000/100 ml. Opposite the junction of Lanceford Creek and Bells River with the Amelia River and directly offshore from the City of Fernandina Beach, there was a median total coliform bacteria density of 2,300/100 ml

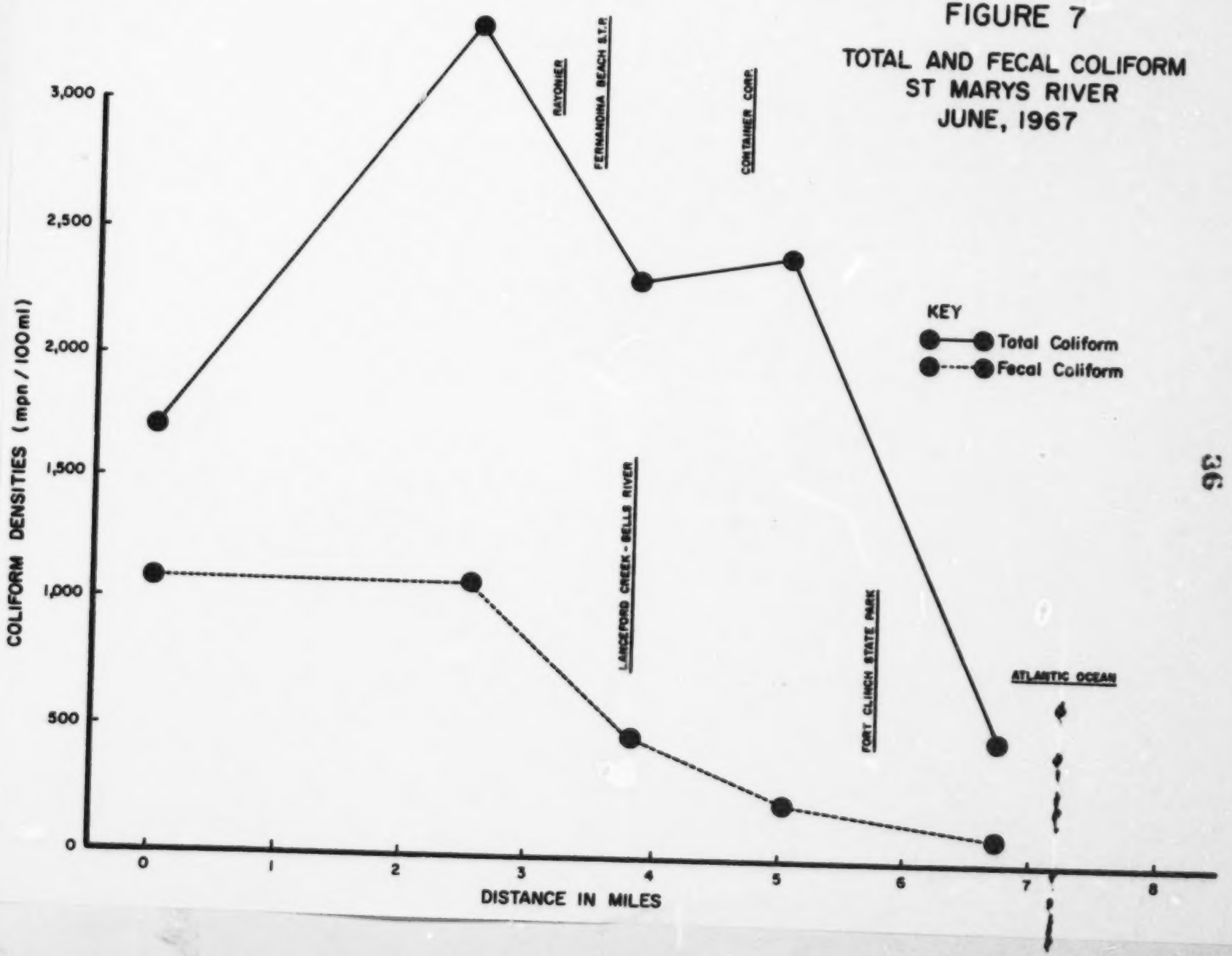
TABLE IV

COLIFORM BACTERIA DENSITIES
ST. MARYS RIVER STUDY AREA
November 1965

Station	Location	Coliform Bacteria Densities (MPN/100 ml) TOTAL Median	TOTAL Maximum	FECAL Median	FECAL Maximum
Amelia River					
649080	Railroad Bridge Just North Of Hwy A1A Bridge	1,700	4,900	1,100	3,300
649060	Buoy #1 In Amelia Riv. South Of Rayonier Outfall	3,300	13,000	1,100	3,300
649040	Buoy #22 In Amelia Riv. Opposite Juncture of Lancefore Creek	2,300	17,000	490	7,900
649020	South of Egans Creek & North Of Container Corp. Outfall	2,400	9,200	230	3,500
St. Marys River					
649200	Near Point Peter	230	3,300	130	460
649260	Approximately Five Mi. Upstream Of St. Marys, Georgia	230	700	50	120
649010	St. Marys Riv. Entrance On Seaward Side of Fort Clinch	490	1,700	110	790
Cumberland Sound					
128710	In Channel @ Mouth Of Cumberland Sound	240	2,400	27	230
North River					
128750	Approx. Four Mi. North Of Gilman Co. Outfall	1,100	7,900	220	3,300
Bells River					
649045	Approx. One Mi. South Of Jolly Riv. & 4.5 Mi. West Of Amelia River	540	920	120	330

FIGURE 7

TOTAL AND FECAL COLIFORM
ST MARYS RIVER
JUNE, 1967



with a maximum value of 17,000/100 ml. During flood current, water at this point is moved into Lanceford Creek and Bells River, which are two of the major potential shellfish nurseries and harvesting areas. South of Egans Creek and the Fort Clinch State Park the median total coliform bacteria density was 2,400/100 ml with a maximum of 9,200/100 ml.

Fecal coliform bacteria densities, which are presumed to result directly from discharges of improperly disinfected domestic sewage, had a median of 1,100/100 ml in the Amelia River south of all waste discharges, but declined to levels of 490/100 ml and 230/100 ml near the confluence of the Amelia and St. Marys Rivers. Maximum fecal coliform bacteria densities were greater than 3,300/100 ml at all stations except at the mouth of Lanceford Creek and Bells River where the maximum was 7,900/100 ml.

The coliform densities in the Amelia River are significantly higher than those observed in other sections of the study area and are the result of untreated and inadequately treated sewage and industrial wastes discharged from Rayonier Inc., Container Corporation of America and the City of Fernandina Beach. Densities in the section of the river near Fort Clinch State Park exceed the 1,000/100 ml standard of total coliform considered minimal for direct contact recreation use.

Median total and fecal coliform densities in the St. Marys River near Point Peter downstream from the juncture with the North River were 230/100 ml and 130/100 ml, while maximum values were 3,300/100 ml and 460/100 ml, respectively. It is difficult to conclude how much of these concentrations is the result of the Gilman Paper Company discharge to the North River because of the great dilution afforded by the St. Marys River and the upstream background concentrations of 230/100 ml and 50/100 ml for

total and fecal coliform, respectively. However, a point in the North River affected by the wastes from Gilman Paper Company had median total and fecal coliform densities of 1,100/100 ml, and 220/100 ml, and maximum densities of 7,900/100 ml and 3,300/100 ml respectively. These data and the dye study results indicate that the Gilman Paper Company discharge have measurably affected bacterial densities in the St. Marys River. These bacterial densities would be significantly reduced by proper treatment of the waste.

Total and fecal coliform bacteria densities at the mouth of Cumberland Sound were 240/100 ml and 27/100 ml, respectively. Cumberland Sound is presently closed to shellfishing by Georgia because of bacterial pollution. Because of the nature of the current cycle, it is very unlikely that Cumberland Sound is adversely affected by waste discharges in the study area.

In the St. Marys channel on the seaward side of Fort Clinch, the median total and fecal coliform bacteria densities were 490/100 ml and 110/100 ml with maximums of 1,700/100 ml and 790/100 ml, respectively. This represents an increase over values found in the St. Marys River and indicates that bacteria at this location is affected by the higher bacterial densities observed in the Amelia River.

The upper reaches of the Bells River strait which should be representative of the shellfish nursery and harvesting areas in Florida had median total and fecal densities of 540/100 ml and 120/100 ml, respectively. Total coliform densities below 110/100 ml were observed. Water movement at this location is primarily affected by the Amelia River. Because of this water movement and bacterial densities observed, it is concluded

that the major contributors to bacterial pollution in these Florida shellfishing areas are the wastes discharged at Fernandina Beach. Proper treatment and disinfection of these wastes should be required before the area can be made available for shellfishing use.

BIOLOGY

No extensive biological studies have been made in the area and, consequently, a detailed evaluation of the effects of the waste discharges on aquatic fauna and flora throughout the study area cannot be made in this report. Pulp and paper wastes contain settleable waste solids which form sludge deposits. These deposits damage bottom organisms and produce water quality degradation as well as cause general aesthetically unattractive conditions. The waste liquors from pulp and paper processing mills have been shown to damage immature forms of fish and shellfish. They may adversely affect oyster production by imparting an impalatable taste.

Bottom samples taken during June 1967 from the Amelia River and North River showed extensive organic deposits in the vicinity of the industrial waste discharges. The sludge banks in the North River contained large quantities of fibrous material associated with paper processing. In unpolluted waters there are many species of bottom organisms; but, because of competition and predation, there are relatively few numbers of each kind. However, as a result of organic wastes discharged to the Amelia River and North River, there was a reduction in the numbers of organism species. Settleable solids blanketing the river bottom have reduced the pollution sensitive form of macroinvertebrates while the number of pollution tolerant species have increased. Samples from the

Amelia River and North River contained only two species of worms which are indicative of a heavily polluted condition. Bottom samples from Cumberland Sound exhibited diverse populations of organisms including many pollution intolerant species, thereby indicating a healthy ecological environment. This is consistent with the other water quality data which show no adverse effects on Cumberland Sound from waste discharges in the study area. The Bureau of Sport Fisheries and Wildlife conducted a bottom sampling survey of the study area during April 1966. Since no living organisms were found in any of the samples collected north of the AlA bridge in the Amelia River, it was concluded that the bottom materials in the area were of an unproductive type for the support of organisms. Large numbers of an extremely pollution tolerant worms were observed swimming in the Fernandina Beach boat basin.

Water quality changes sufficient to alter the ecology of the bottom dwelling fauna will also alter the fish population and variety of species which utilize these bottom organisms as a food supply. Reductions in pollution sensitive bottom forms of organisms indicate that fish population will likewise be adversely affected. In sampling conducted over a current cycle in the St. Marys River by the Bureau of Sport Fisheries and Wildlife in the Spring of 1966, 304 fish were taken upstream from the North River, but only 128 fish were taken downstream from the North River. Fish can exhibit an avoidance reaction to undesirable water quality conditions, and these findings support the conclusion that the major effects of the Gilman Company waste discharge occur in the St. Marys River downstream from the confluence with the North River. Both Sampling stations were in the direct path of the effluent.

The effect of these wastes on attached organisms, such as oysters, in the Amelia River is striking. These organisms cannot exhibit an avoidance reaction, and their well being depends on the maintenance of water quality acceptable to them. Although there is an abundance of substrate suitable for oyster production along the Fernandina Beach waterfront from about 0.4 miles north of the Container Corporation outfall to well below the Rayonier mill, no living oysters are found. Living oysters were, however, observed on the west bank of the Amelia River wherever suitable substrate was available.

There is an acute toxic effect on bottom and attached organisms in the vicinity of the waste discharges from the three paper companies. The chronic effects of these wastes throughout the study area have not been evaluated. Fish and other mobile species will avoid contact with these effluents where they are present in significant concentrations.

APPENDIX A

RESOLUTION TO INFORM THE GOVERNOR'S COMMITTEE ON POLLUTION AND THE STATE BOARD OF HEALTH OF THE INFORMATION RECEIVED AT PUBLIC HEARING ON WATER POLLUTION

WHEREAS, the Board of County Commissioners of Nassau County, Florida, was requested to hold a public hearing on water pollution of the Amelia River and its contributaries, which meeting was held on June 6, 1967, at 8:00 o'clock P.M. after public notice, at which meeting approximately sixty interested persons were in attendance, and

WHEREAS, each of those in attendance at said hearing was given an opportunity to be heard and numerous persons spoke in regard to the water pollution problem, and

WHEREAS, the pertinent facts brought out in the proceedings of this hearing were as follows:

1. That Fort Clinch State Park, located on the north end of Amelia Island at the northern terminus of the Amelia River, is visited by many thousands of people each year, some of whom camp with their families at the camping facilities of this park for extended periods of time, and that numerous people participate in water-contact sports such as swimming and skiing at this location on the Amelia River, although this area is posted as being dangerous to swimmers, which was done prior to the knowledge of the pollution of the Amelia River because of the dangerous currents in the river at this point.

2. That because of the nature of the pollution of the river, it is unsafe for bodily contact, which includes not only swimmers but those persons who come in bodily contact with the waters of the river in a commercial or recreational manner in the handling of boats and the pertinences thereto, including launching, repair, and other activities which necessitate bodily contact with the waters of the river.

3. That the City of Fernandina Beach, Florida, has erected, and the Florida Development Commission operates, the only Marine Welcome Station in the world, said station being located at the foot of Atlantic Avenue in the City of Fernandina Beach, Florida, on the Amelia River, where all pleasure craft plying the inland waterway is invited to dock at the wharf facilities, thereby exposing all of these visitors to the contamination of the polluted waters of the Amelia River.

4. That the Amelia River and its contributaries are spawning grounds for shrimp, shellfish, and other types of marine life, and, due to the pollution of the river as it now exists, spawning activities are adversely affected and many of the living species are killed or otherwise diseased so that the eatable varieties are not fit for human consumption.

5. That the basic cause of the pollution of the Amelia River and its contributaries is due to the dumping of raw sewage, chemical effluence, waste products from the fishing

industries, and waste from other businesses and industries located on the banks of the Amelia River in this area.

WHEREAS, this Board feels that the matters and things presented at the public hearing should be transmitted to the Governor's Committee on Pollution and the Florida State Board of Health for their consideration.

NOW, THEREFORE, BE IT RESOLVED by the Board of County Commissioners of Nassau County, Florida, in special meeting duly assembled, that the Governor's Committee on Pollution and the Florida State Board of Health be, and they are, hereby informed as to the public meeting held in the Nassau County Courthouse in regard to water pollution and the pertinent facts presented at such meeting as set forth in the preamble hereto for their consideration regarding water pollution of the Amelia River and its contributaries and the appropriate classification thereof.

BE IT FURTHER RESOLVED that a copy of this resolution be forwarded to the Governor's Committee on Pollution, the Florida State Board of Health, and the Nassau County Water Pollution Association.

ADOPTED this 6th day of June, 1967.

/s/ John F. Armstrong, Jr.
CHAIRMAN
BOARD OF COUNTY COMMISSIONERS
NASSAU COUNTY, FLORIDA

APPENDIX B

CRITERIA FOR CLASSIFICATION OF WATERS

A. FLORIDA

170C-5.08 Criteria: Class II Waters - shellfish harvesting. -

The following criteria are for classification of waters in areas to be utilized for shellfish harvesting:

(1) Bacteriological Quality, Coliform Group - areas classified for shellfish harvesting, the median coliform MPN (Most Probable Number) of water cannot exceed seventy (70) per hundred (100) ml., and not more than ten (10) percent of the samples ordinarily exceed an MPN of two hundred and thirty (230) per one hundred (100) ml in those portions of areas most probably exposed to fecal contamination during most unfavorable hydrographic and pollution conditions. (2) Sewage, Industrial Wastes, or Other Wastes - any industrial wastes or other wastes shall be effectively treated by the latest modern technological advances as approved by the regulatory agency. (3) pH - of receiving waters shall not be caused to vary more than one (1.0) unit above or below normal pH of the waters; and lower value shall be not less than six (6.0) and upper value not more than eight and one-half (8.5). In cases where pH may be, due to natural background or causes, outside limits stated above, approval of the regulatory agency shall be secured prior to introducing such material in waters of the state.. (4) Temperature - shall be less than ten percent (10%) increase of prevailing background temperature after reasonable mixing with a 93°F temperature maximum, providing that such limitations will not apply to the use of such waters for bathing or other body contact activities, or to the use of

such waters for cooling purposes, unless the regulatory agency shall find that such use is damaging to such waters or to the aquatic life therein. (5) Dissolved Oxygen - shall not be artificially depressed below the values of four (4.0) ppm or seventy percent (70%) saturation (unless background information available to the regulatory agency indicates prior existence under unpolluted conditions of lower values). In such cases, lower limits may be utilized after approval by the regulatory authority. (6) Toxic Substances - free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic or harmful to humans, animal or aquatic life. (7) Odor - threshold odor number not to exceed 24 at 60°C as a daily average.

170C-5.09 Criteria: Class III Waters - Recreation - Propagation and management of fish and wildlife.

The following criteria are for classification of waters to be used for recreational purposes, including such body-contact activities as swimming and water skiing; and for the maintenance of a well-balanced fish and wildlife population.

(1) Sewage, industrial wastes, or other wastes - any industrial waste or other wastes shall be effectively treated by the latest modern technological advances as approved by the regulatory agency.

(2) pH - of receiving waters shall not be caused to vary more than one (1.0) unit above or below normal pH of the waters; and lower value shall be not less than six (6.0), and upper value not more than eight and one-half (8.5). In cases where pH may be, due to natural background or causes outside limits stated above; approval of the regulatory agency shall be secured prior to introducing such material in waters of the state.

(3) Dissolved Oxygen - shall not be artificially depressed below the values of four (4.0) ppm or seventy percent (70%) saturation (unless background information available to the regulatory agency indicates prior existence under unpolluted conditions of lower values). In such cases, lower limits may be utilized after approval by the regulatory authority.

(4) Bacteriological - coliform group not to exceed 1,000 per 100 ml as a monthly average, (either MPN or MF counts); nor to exceed this number in more than 20% of the samples examined during any month; nor exceed 2,400 per 100 ml (MPN or MF count) on any day. This criteria shall apply only to waters used for body contact activities.

(5) Toxic substances - free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic or harmful to humans, animal or aquatic life.

(6) Deleterious - free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor or other conditions in such degree as to create a nuisance.

(7) Turbidity - shall not exceed fifty (50) Jackson units as related to standard candle turbidimeter above background.

(8) Temperature - shall be less than ten percent (10%) increase of prevailing background temperature after reasonable mixing with a 93°F temperature maximum, providing that such limitations will not apply to the use of such waters for bathing or other body contact activities, or to the use of such waters for cooling purposes, unless the regulatory agency shall find that such use is damaging to such waters or to the aquatic life therein.

170C-5.11 Criteria: Class V Waters - Navigation, utility and industrial use. -

The following criteria are for classification of waters which will be suitable for navigation and any other uses except for waters previously classified in this Chapter:

(1) Sewage, Industrial or Other Wastes - none which are not effectively treated or controlled to the satisfaction of the regulatory agency.

(2) pH - not lower than 5.0 nor greater than 9.5 except certain swamp waters which may be as low as 4.5.

(3) Dissolved oxygen - sufficient to be aerobic.

(4) Odor producing substances - only in such amounts that will not unreasonably interfere with the use of the water for the designated purpose of this classification.

B. GEORGIA

730-3-.05 SPECIFIC CRITERIA FOR CLASSIFIED WATER USAGE -

The following criteria are deemed necessary and shall be required for the specific water usage as shown:

(2) Recreation - General recreational activities such as water skiing, boating and swimming, or for any other use requiring water of a lower quality. These criteria are not to be interpreted as condoning water contact sports in proximity to sewage or industrial waste discharges regardless of treatment requirements imposed on such waters.

(a) Bacteria: Fecal coliform not to exceed a mean of 1,000 per 100 ml (MPN) based on at least four samples taken over a 30-day period, and not to exceed 4,000 per 100 ml in more than five percent of the samples taken in any 90-day period.

(b) Dissolved Oxygen: Not less than 4.0 mg/l except that those streams designated as trout waters by the State Game and Fish Commission must have a minimum of 5.0 mg/l at all times.

(c) pH: Within the range of 6.0 - 8.5.

(d) Toxic Wastes, Other Deleterious Materials: None in concentrations that would harm man, fish and game or other beneficial aquatic life.

(e) Temperature: Not to exceed 93.2°F. (34.0°C) at any time and not to be increased more than 10°F above intake temperature. In streams designated as trout waters by the State Game and Fish Commission, there shall be no elevation or depression of natural stream temperatures.

(3) Fishing, Propagation of Fish, Shellfish, Game and Other Aquatic Life; or for any other use requiring water of a lower quality.

(a) Dissolved Oxygen: A minimum of 5.0 mg/l at all times for streams designated as trout waters by the State Game and Fish Commission; a minimum of 4.0 mg/l at all times for waters supporting warm water species of fish.

(b) pH: Within the range of 6.0 - 8.5.

(c) Bacteria: Fecal coliform not to exceed a mean of 5,000 per 100 ml (MPN) based on at least four samples taken over a 30-day period and not to exceed 20,000 per 100 ml in more than five percent of the samples in any 90-day period.

(d) Bacteria: (Applicable only to shellfish to be commercially harvested). Total coliform group not to exceed a median MPN of 70 per 100 ml, and not more than 10 percent of the samples shall exceed an MPN of 230 per 100 ml for a 5-tube decimal test (or 330 per 100 ml where a 3-tube decimal dilution is used) in those areas most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.

(e) Temperature: Not to exceed 93.2°F (34.0°C) at any time and not to be increased more than 10°F above intake temperature. In streams designated as trout waters by the State Game and Fish Commission, there shall be no elevation or depression of natural stream temperatures.

(f) Toxic Wastes, Other Deleterious Materials: None in concentrations that would harm man, fish and game or other beneficial aquatic life.